

in northern Ventura County, California. This lower Miocene (Zemurian?-Saucian) member, which contains mostly parallel-bedded, cross-bedded, massive sandstone and some pebble conglomerate, is exposed in a 35-km band of outcrops paralleling upper Sespe Creek. Sandstone of the cross-bedded part is a calcitic, medium-grained, moderately sorted arkose. Fossils present include *Ostrea eldridgei*, *Lyropecten*, magnolia, *Vertipecten nevadanus*, *Isurus* sp., *Demostylus* sp., and additional vertebrate remains.

Cross-bedding in the member has its thickest exposure and is most continuous at Piedra Blanca, where tabular and cross-bedded sets 1 to 2 m thick reach a total thickness of 80 m. Foreset slopes average 22° and, following restoration to horizontal, face south and southeast. At Kimball Canyon, 8 km east of Piedra Blanca, trough-cross-bedded sets are up to 10 m thick. Elsewhere along Sespe Creek the cross-bedded part of the member ranges from 0 to 20 m thick and consists of tabular, wedge, and trough shapes in smaller sets 0.2 to 1.5 m thick. Foresets all face south and southeast.

The upper member of the Vaqueros Formation was deposited as an extensive early Miocene submarine sand sheet which contained several small dune fields. Straight-crested and lunate dunes were present in a dune field at Piedra Blanca and large lunate dunes occurred in a smaller field at Kimball Canyon. Straight-crested and lunate dunes and smaller ripples also were scattered elsewhere on the sand sheet. All dune and ripple features were migrating to the south and southeast under a unidirectional current that swept across the entire sand sheet. Such a current probably was not tidally influenced.

SALEEBY, J., S. GOODIN, C. BUSBY, and W. SHARP, Dept. Geol. and Geophys., Univ. California, Berkeley, Calif.

#### Early Mesozoic Paleotectonic-Paleogeographic Reconstruction of Southern Sierra Nevada Region

A paleotectonic-paleogeographic reconstruction was based on structural, petrologic, and geochronologic studies of pre-Sierra Nevada batholith framework rocks exposed between the San Joaquin River and the Garlock fault. Most available fossil data from roof pendants of this region indicate Late Triassic to Early Jurassic ages. An additional fossil locality from the western wall rocks yields a Late Permian Tethyan fauna. This is a maximum age for the enclosing rocks, for the fossils are in a limestone olistolith. As yet there is no sign of Paleozoic strata in the region except perhaps along the eastern Sierran crest in small metamorphic septa, and in the western foothills where ophiolitic rocks are present.

The paleobasement geology of the southern Sierra consists of two contrasting terranes both of which were allochthonous. The western terrane is exposed along the western foothills. It consists of the Kings-Kaweah ophiolite belt, a latest Paleozoic to possibly earliest Mesozoic remnant of disrupted oceanic lithosphere. The ophiolite belt appears to represent an oceanic fracture-zone complex that was transported northward into the region by large-scale wrench faulting. The eastern terrane can only be inferred from petrochemical studies on

the batholith. This terrane was sialic in character. It also appears to have been displaced northward by wrench faulting, but of a lesser magnitude. The zone of joining between the eastern continental terrane and the western oceanic terrane is termed the "foothill suture."

Early Mesozoic strata were deposited on both paleobasement terranes. Strata of the oceanic terrane consist of: (1) chert-argillite olistostromes containing exotic blocks of Late Permian limestone and local blocks of quartzitic sandstone; (2) quartzitic to subarkosic flysch; (3) olistostromes derived from ophiolite basement rocks; and (4) basalt-andesite volcanic rocks typical of an oceanic island arc. Strata of the continental terrane consist of: (1) quartzose to subarkosic flysch; (2) quartzite-argillite olistostromes with large slide blocks of shallow-water limestone; (3) massive quartzitic to subarkosic sandstones and thinner calcareous sandstones; and (4) silicic volcanic rocks typical of an ignimbrite terrane.

The flysch sequences of each terrane apparently are correlative. The eastern sequence contains a more proximal facies; the western a more distal facies. The western facies flysch was partly reworked and includes chert-argillite olistostromes.

In our model the early Mesozoic paleogeography of the region was controlled by a complex plate juncture that involved both large-scale wrench movements and oblique subduction. The Triassic was characterized primarily by tectonic truncation of the continental margin by dextral wrench faulting. North-northeast structural and stratigraphic trends typical of the Paleozoic were overprinted by northwest trends which have persisted into present time. The wrench zone extended through the truncated margin and into the oceanic domain. The southern extension of this zone was a large fracture zone that extended to the equatorial and possibly southern proto-Pacific. During northward transport of the fracture-zone complex, slide blocks of shallow-water limestone were acquired from an equatorial oceanic faunal belt. As the fracture-zone complex moved into the proximity of the truncated margin, slices of the continental margin were differentially transported northward. Some fragments were displaced possibly as far as southeastern Alaska, others such as the eastern continental terrane of the southern Sierra underwent much more limited displacements. During the Late Triassic to Early Jurassic a submarine-fan complex was shed from the truncated continental shelf and dispersed across the fracture-zone complex. The sands of this fan complex are believed to be in part an extension of the Navajo-Aztec sands which accumulated on the ancient shelf. At about the same time a change in relative plate motions resulted in a convergent component along the complex plate juncture. The fracture zone complex was stranded as the hanging wall of an oblique subduction zone. Eruption of oceanic arc-type rocks along the western terrane and silicic rocks along the eastern terrane indicate the onset of subduction-related magmatism. Both volcanic assemblages were interstratified with sands of Navajo-Aztec affinity. During arc volcanism both terranes of the southern Sierra continued differential northward transport by intra-arc wrench faulting which dissipated the strike-slip component of oblique subduction. Volcanic centers and the submarine-fan complex

were dismembered as they were built. Slide blocks of reef limestone were shed from the shelf and the quartzitic sands were reworked into olistostrome deposits. Basement uplifts in the western terrane shed ophiolite-assemblage olistostromes and triggered reworking of the chert-argillite olistostrome complex.

The tectonic regime proposed is considered applicable to the early Mesozoic of California in general. The truncation event and the establishment of northwest tectonic trends may be the signature of a major change in plate-motion patterns. This change is thought to have been characterized by the onset of large-scale northward drift of Pacific ocean floor relative to North America. This pattern has persisted into present time.

SHERWOOD, JOHN W., PHILIP SCHULTZ, and DAVID JUDSON, Digicon Geophysical Corp., Houston, Tex.

#### Equalizing Stacking Velocities of Dipping Events

It is well known that a steeply dipping primary reflection requires a higher CDP stacking velocity than a time-coincident flat-dip primary reflection. Thus, important steep-dip seismic events, such as fault-plane reflections and the limbs of diffraction patterns, that may be present in the pre-stack data typically are rejected from a conventional CDP stack section.

In an attempt to remedy this situation Digicon has implemented DEVILISH, a novel procedure which can be applied to uniformly recorded seismic data prior to CDP stack. From an interpreted and approximate flat-dip stacking velocity function, which may change slowly along the assumed dip line, DEVILISH designs time-varying, multi-CDP filters for application to the pre-stack data. These filters have the property of leaving a zero-offset section completely unaltered. For nonzero offsets there is no change of flat-dip events, but steep-dip events are given the approximate theoretical space-time adjustment that will lead to their optimal stack using the flat-dip velocity function. The resulting CDP stack should then display those steep-dip primary reflections which were sampled adequately in the basic seismic data and which conform to the inherent assumptions and approximations mentioned.

Departures from the ideal clearly will result in a suboptimum stack section, but in all realistic situations the DEVILISH stack section should be significantly closer to optimality than the conventional stack.

SHOHAM, YORAM, Geotronics Corp., Austin, Tex.

#### Magnetotelluric Geophysical Exploration Method—a Review

The use of magnetotelluric soundings for the estimation of subsurface electrical conductivity structures has been increasing during the past several years. The method currently is applied to a large variety of structural and stratigraphic exploration problems which can be resolved using knowledge of the nature of the electrical conductivities and their spatial-structural distribution. Such problems encompass petroleum, geothermal, mineral, and groundwater exploration.

SMITH, JOHN L., Republic Geothermal, Inc., Santa Fe Springs, Calif.

#### Geologic Interpretations for Reservoir and Fluid-Flow Rate Variations in Northern East Mesa Geothermal Wells

Completion intervals of geothermal production wells drilled within the northern part of the East Mesa field have been selected to include those parts of the reservoir with temperatures above a thermal threshold of 325°F (163°C). The variations in the permeability-thickness values calculated for completions are reflected in observed differences in well-fluid flow rates.

Detailed studies of the well logs and available geophysical information, including modern Vibroseis data, demonstrate that deltaic reservoir rocks below 2,000 ft (600 m) are a vertically alternating sequence of sandstone and shale units that are stratigraphically correlative but now structurally displaced by gravity faults, folding, and strike-slip faults. Differences in reservoir character and well productivity are explained by a combination of factors that primarily include structural location and a retention of primary matrix porosity.

SOLOMON, BARRY J., EDWIN H. MCKEE, CHARLES A. BROOK, U.S. Geol. Survey, Menlo Park, Calif., and J. WARD SMITH, Laramie Energy Research Center, Laramie, Wyo.

#### Tertiary Geology and Oil Shale Resources of South Elko Basin, Nevada

As much as 470 m of middle Cenozoic petroliferous lacustrine strata is exposed in the south Elko basin, unconformably overlying the Mississippian and Pennsylvanian Diamond Peak Formation. The lower 95 m consists of lean oil shale, mudstone, and limestone, with minor sandstone, conglomerate, and air-fall tuff. The tuff has been K-Ar dated at  $43.3 \pm 0.4$  m.y. These informally named rocks are conformably overlain by, and appear to be closely related to, strata of the Elko Formation. The Elko Formation is 375 m thick and is divided into five informal members. In ascending order they are: (1) chert-pebble conglomerate with interbedded lean oil shale and mudstone; (2) rich oil shale with interbedded siltstone and minor lignite; (3) lean oil shale, mudstone, and minor thin beds of calcareous siltstone and limestone (the lateral equivalent of members 1 and 2); (4) tuffaceous siltstone overlain by lean oil shale, mudstone, siltstone, and minor tuff and lignite; and (5) air-fall tuff overlain by shale, siltstone, tuff, and ash beds. A K-Ar age from near the base of the fifth member is  $38.8 \pm 0.3$  m.y. The Indian Well Formation overlies the Elko Formation and consists of approximately 600 m of fluvial strata and air-fall tuff.

Analyses of oil shale indicate a yield of up to 360 l/ton of 24 to 34° API oil. The oil shale is noncoking. Preliminary estimates indicate resources of approximately 150 million bbl of oil.

The Indian Well Formation and older rocks generally dip eastward and are cut by normal faults. They are overlain unconformably by unnamed subhorizontal beds of air-fall tuff and andesite dated at  $37.1 \pm 1.0$  and  $31.0 \pm 1.0$  m.y., respectively. Local remnants of nonpe-